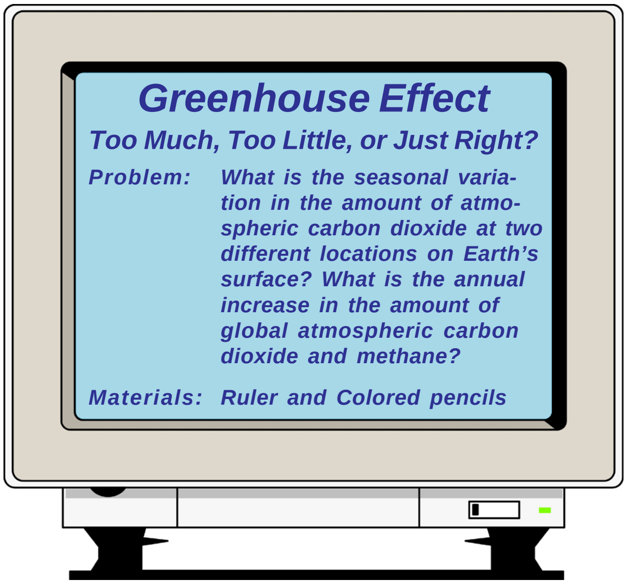
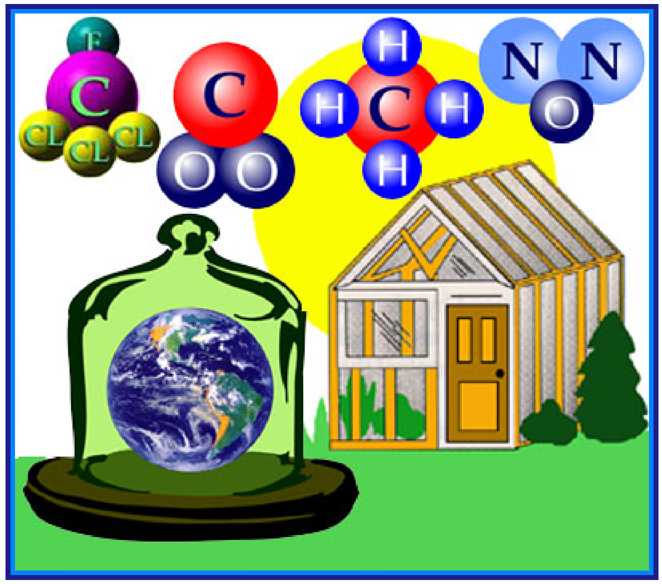




Background

Venus and Earth are about the same size and so close that they are frequently called the “twin planets” of our solar system. Yet, Venus is so hot that lead will melt on its surface! A runaway greenhouse effect makes Venus this hot. The greenhouse effect occurs when the atmosphere of a planet acts much like the glass in a greenhouse. Like the greenhouse glass, the atmosphere allows visible solar energy to pass through, but it also prevents some energy from radiating back out into space.

The greenhouse effect insures that the surface of a planet is much warmer than interplanetary space because the atmosphere traps heat in the same way a greenhouse traps heat. Certain gases, called greenhouse gases, tend to reflect radiant energy from the Earth back to the Earth’s surface, improving the atmosphere’s ability to trap heat. All greenhouse gases are trace gases existing in small amounts in our atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, some chlorofluorocarbons, and water vapor.

We know that the greenhouse effect is necessary for survival. Without it, the Earth would be so cold that life as we know it couldn’t exist. However, scientists still have questions that must be answered. What kinds and amounts of greenhouse gases are necessary for survival? Are the amounts of greenhouse gases increasing, decreasing, or remaining the same? To answer these questions, scientists monitor the amounts of greenhouse gases in the Earth’s atmosphere.

The atmospheric gas most responsible for the warming effect on both Venus and Earth is carbon dioxide (CO_2). On both planets, a primary source of CO_2 is volcanic eruptions. The difference between these two planets is that on Venus, 97% of the atmosphere is CO_2, whereas on Earth, muc h less than one percent of the atmosphere is CO_2. Why is there so much less CO_2 on Earth? The carbon cycle holds the answer.

In the natural cycle of carbon, plants take in CO_2 and give off oxygen (O_2), whereas animals take in O_2 and emit CO_2. Further, CO_2 dissolved in seawater is used by plants during photosynthesis and by other seawater organisms, such as clams and coral, to produce calcium carbonate ($CaCO_3$) shells. These processes help control the amount of CO_2 in our atmosphere.

Human beings complicate the natural carbon cycle because they increase the amount of CO_2 in Earth's atmosphere by burning fossil fuels. Driving automobiles, heating buildings, and producing consumer goods all add to the concentration of CO_2 in Earth's atmosphere.

Methane (CH_4) is another greenhouse gas. It is produced in swamps, bogs, and rice paddies, as well as in the intestinal tracts of most animals, including cattle, sheep, and humans. Coal, oil, and gas exploration also contribute to the accumulation of CH_4 in the atmosphere. However, CH_4 concentrations are much less than CO_2 concentrations.

Nitrous oxide (N_2O), or "laughing gas," is another greenhouse gas accumulating in the atmosphere, although not as fast as CH_4. Fertilizer decomposition, industrial processes that use nitric acid, and small amounts from automobile emissions all contribute to increasing atmospheric N_2O.

In the procedures (Parts A and B) for this activity, you will plot curves for the CO_2 (ppm) and CH_4 (ppb) concentrations found in the atmosphere over an extended period of time. In much the same way a scientist would monitor concentrations of gases in the atmosphere, you will look for changes and trends, as well as maximum and minimum concentrations during that same extended time period. The 20-plus year data record in Tables 6.1a, 6.1b, 6.1c, 6.1d, and 6.2 of this activity was provided by the National Oceanic and Atmospheric Administration (NOAA) - Climate Monitoring and Diagnostics Laboratory (CMDL), Boulder, Colorado.

Procedure

Part A

1. Using the data from Tables 6.1a and 6.1b, plot the points corresponding to the monthly mean CO_2 concentration at Point Barrow, Alaska on the graphs that follow. Use a colored pencil to connect the points.

2. Using the data from Tables 6.1c and 6.1d, plot the points corresponding to the monthly mean CO_2 concentration at South Pole Station, Antarctica on the graphs that follow. Use a different colored pencil to connect the points.

3. Print a title at the top of your graphs.

4. Place a color-coded legend on your graphs in the space provided.

Point Barrow, Alaska - I

Month Of Year	1971	1972	1973	1974	1975	1976	1977	1978
January	-	333.45	334.71	336.95	337.00	338.13	338.34	339.69
February	-	334.79	335.42	337.58	337.05	339.02	338.17	341.07
March	-	335.27	336.47	337.43	336.84	339.40	338.75	340.83
April	-	335.62	336.94	337.39	336.70	339.27	339.84	340.85
May	-	336.05	336.57	338.79	336.83	338.63	340.15	340.80
June	330.22	333.39	334.02	338.20	335.56	336.29	338.06	338.94
July	323.65	325.63	327.51	330.50	330.09	330.34	331.93	333.36
August	317.73	319.10	322.27	323.09	324.78	325.10	326.80	327.40
September	318.78	322.04	323.49	323.73	325.46	325.58	327.08	327.70
October	322.84	327.25	328.26	328.94	329.76	329.94	330.39	332.39
November	327.32	330.67	332.05	333.25	333.63	333.39	334.40	337.09
December	331.05	333.46	334.74	335.76	336.52	336.66	337.19	339.05
Month Of Year	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
January	340.18	341.97	344.75	346.14	346.57	349.00	349.43	350.73
February	341.51	342.76	345.39	347.26	347.14	350.37	349.36	352.93
March	342.28	343.23	345.44	347.78	347.59	349.94	350.35	353.39
April	342.47	344.31	345.97	347.54	347.87	349.66	351.77	353.07
May	343.40	345.15	346.47	347.63	348.26	350.33	352.14	353.06
June	341.54	342.90	343.85	345.66	346.53	348.36	349.54	350.33
July	334.03	337.26	336.38	339.52	339.84	341.32	343.45	343.96
August	327.56	332.21	330.83	333.31	333.79	335.91	337.24	338.80
September	329.20	332.54	332.61	333.20	333.95	337.47	338.35	341.91
October	334.74	336.95	338.25	338.37	340.41	341.41	343.52	347.50
November	338.29	340.60	342.11	342.34	345.25	344.85	347.32	350.36
December	340.01	342.98	344.48	344.87	347.00	348.12	348.87	352.04

Table 6.1a. Point Barrow, Alaska Monthly Carbon Dioxide Data

Point Barrow, Alaska - II

Month Of Year	1987	1988	1989	1990	1991	1992	1993	1994
January	353.10	355.63	359.02	360.66	361.78	361.86	362.52	362.61
February	353.70	357.06	358.66	361.12	361.75	362.07	362.75	364.24
March	354.09	357.28	359.67	361.71	362.15	362.38	363.37	364.85
April	354.34	357.84	360.03	361.66	362.17	362.79	363.70	364.17
May	354.98	357.66	359.44	361.48	361.91	362.56	363.48	364.42
June	352.91	354.97	358.43	356.81	360.10	360.24	359.65	362.12
July	345.80	348.04	350.88	348.54	353.61	354.01	352.35	353.39
August	339.99	343.13	342.81	344.64	346.90	347.36	347.97	347.75
September	340.89	345.13	345.15	346.97	348.48	348.29	349.88	350.43
October	345.66	350.54	351.64	352.81	354.68	352.76	354.61	356.38
November	349.81	355.01	356.02	356.60	358.58	356.85	359.00	361.49
December	352.66	358.16	359.36	359.83	360.55	360.78	361.23	364.15

Month Of Year	1995	1996	1997	1998	1999	2000	2001
January	365.62	366.87	368.91	369.15	374.13	374.86	375.38
February	366.66	368.09	369.18	370.33	373.78	375.64	376.34
March	366.57	367.95	368.77	370.98	374.12	375.04	376.82
April	366.35	368.05	369.63	370.95	374.63	375.33	377.14
May	366.17	369.40	370.54	371.60	375.39	376.36	-
June	363.69	368.16	367.74	369.72	372.13	373.49	-
July	356.51	361.89	358.94	362.28	364.31	366.32	-
August	351.44	354.70	354.54	357.28	359.02	360.33	-
September	352.96	355.50	357.66	360.11	360.41	361.95	-
October	357.88	361.11	362.15	364.93	365.45	367.07	-
November	363.43	363.70	365.67	369.18	371.43	371.03	-
December	366.00	366.19	367.90	373.00	373.81	373.55	-

Table 6.1b. Point Barrow, Alaska Monthly Carbon Dioxide Data

South Pole, Antarctica - I

Month Of Year	1975	1976	1977	1978	1979	1980	1981
January	-	329.74	331.10	332.25	335.56	336.15	337.81
February	-	329.68	330.72	332.25	335.79	336.11	337.73
March	-	329.65	330.46	332.45	335.72	336.14	337.75
April	-	329.87	330.50	332.87	335.86	336.35	337.96
May	-	330.09	330.65	333.39	336.25	336.65	338.25
June	-	330.22	330.96	333.72	336.48	336.89	338.50
July	329.81	330.61	331.57	334.10	336.94	337.31	338.93
August	330.32	331.14	332.49	334.63	337.56	337.76	339.31
September	330.49	331.61	332.91	335.08	337.60	337.98	339.29
October	330.74	331.97	332.71	335.55	337.67	338.09	339.24
November	330.89	331.94	332.50	335.66	337.62	338.09	339.29
December	330.27	331.52	332.36	335.39	336.81	337.96	339.11

Month Of Year	1982	1983	1984	1985	1986	1987	1988
January	338.87	339.67	341.58	342.81	344.40	345.71	348.14
February	338.61	339.53	341.54	342.91	344.16	345.71	347.93
March	338.46	339.54	341.47	342.83	344.11	345.79	348.03
April	338.73	339.99	341.44	342.82	344.23	345.96	348.29
May	338.99	340.43	341.58	343.11	344.44	346.15	348.44
June	339.07	340.66	341.81	343.39	344.73	346.59	348.70
July	339.37	341.01	342.18	343.85	345.03	347.11	349.13
August	339.83	341.52	342.68	344.39	345.56	347.60	349.58
September	340.13	341.81	343.01	344.58	345.90	348.02	349.83
October	340.18	341.85	343.07	344.64	345.88	348.21	349.96
November	340.03	341.83	343.02	344.62	345.81	348.25	349.95
December	339.80	341.71	342.88	344.51	345.74	348.26	349.89

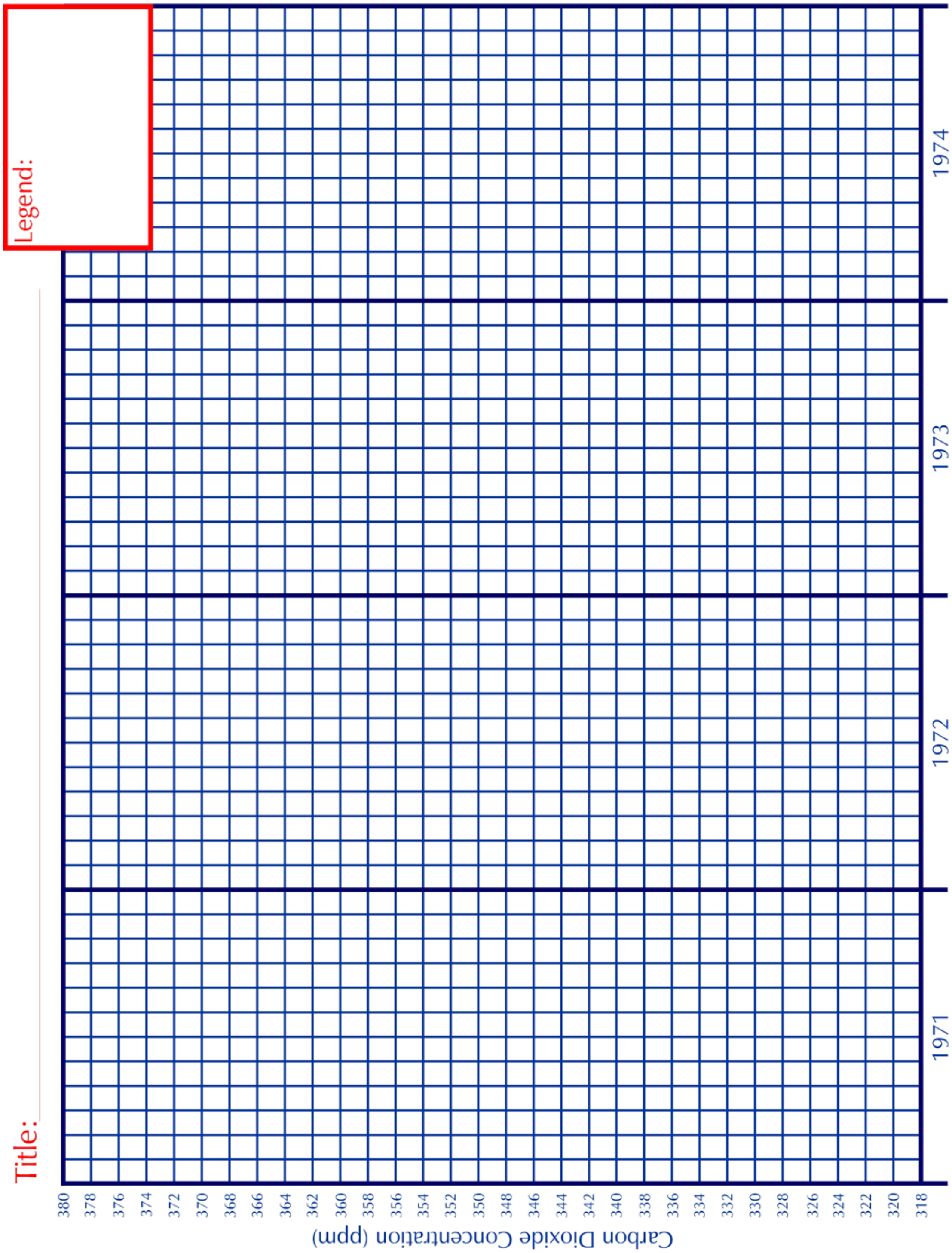
Table 6.1c. South Pole, Antarctica Monthly Carbon Dioxide Data

South Pole, Antarctica - II

Month Of Year	1989	1990	1991	1992	1993	1994	1995
January	349.95	351.15	352.60	353.63	354.63	355.31	357.18
February	349.91	350.90	352.40	353.21	354.44	355.27	357.08
March	349.86	350.80	352.35	353.04	354.29	355.32	357.05
April	349.95	351.06	352.65	353.22	354.22	355.38	357.32
May	350.08	351.50	352.76	353.61	354.34	355.42	357.51
June	350.31	351.71	352.99	354.06	354.67	355.77	357.67
July	350.79	352.04	353.53	354.55	355.13	356.27	358.12
August	351.26	352.43	353.86	354.97	355.54	356.77	358.51
September	351.44	352.64	353.94	355.15	355.71	357.20	358.70
October	351.61	352.79	353.88	355.13	355.70	357.31	359.08
November	351.89	352.78	353.86	355.06	355.58	357.28	359.30
December	351.72	352.65	353.86	354.90	355.43	357.25	359.10

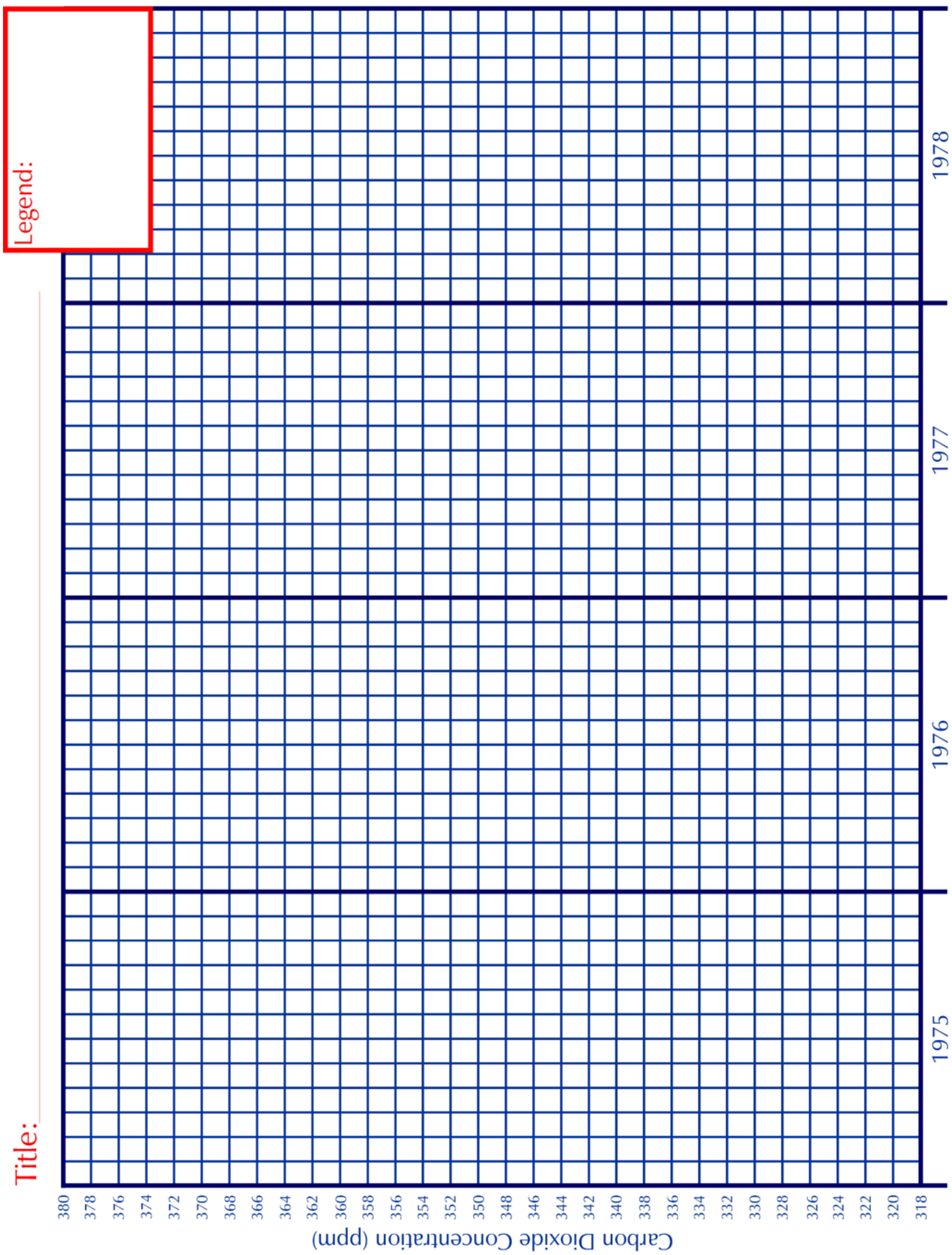
Month Of Year	1996	1997	1998	1999	2000	2001
January	359.03	360.33	362.08	364.97	366.40	367.76
February	359.04	360.29	362.25	364.83	366.21	-
March	359.05	360.25	362.50	364.80	366.07	-
April	359.02	360.36	362.75	364.92	366.11	-
May	359.03	360.65	363.10	365.15	366.29	-
June	359.26	360.95	363.56	365.40	366.52	-
July	359.76	361.19	364.13	365.62	366.93	-
August	360.22	361.54	364.72	366.01	367.40	-
September	360.41	361.86	365.04	366.35	367.60	-
October	360.38	362.00	365.13	366.50	367.69	-
November	360.31	362.10	365.10	366.61	367.80	-
December	360.33	362.11	365.04	366.55	367.81	-

Table 6.1d. South Pole, Antarctica Monthly Carbon Dioxide Data

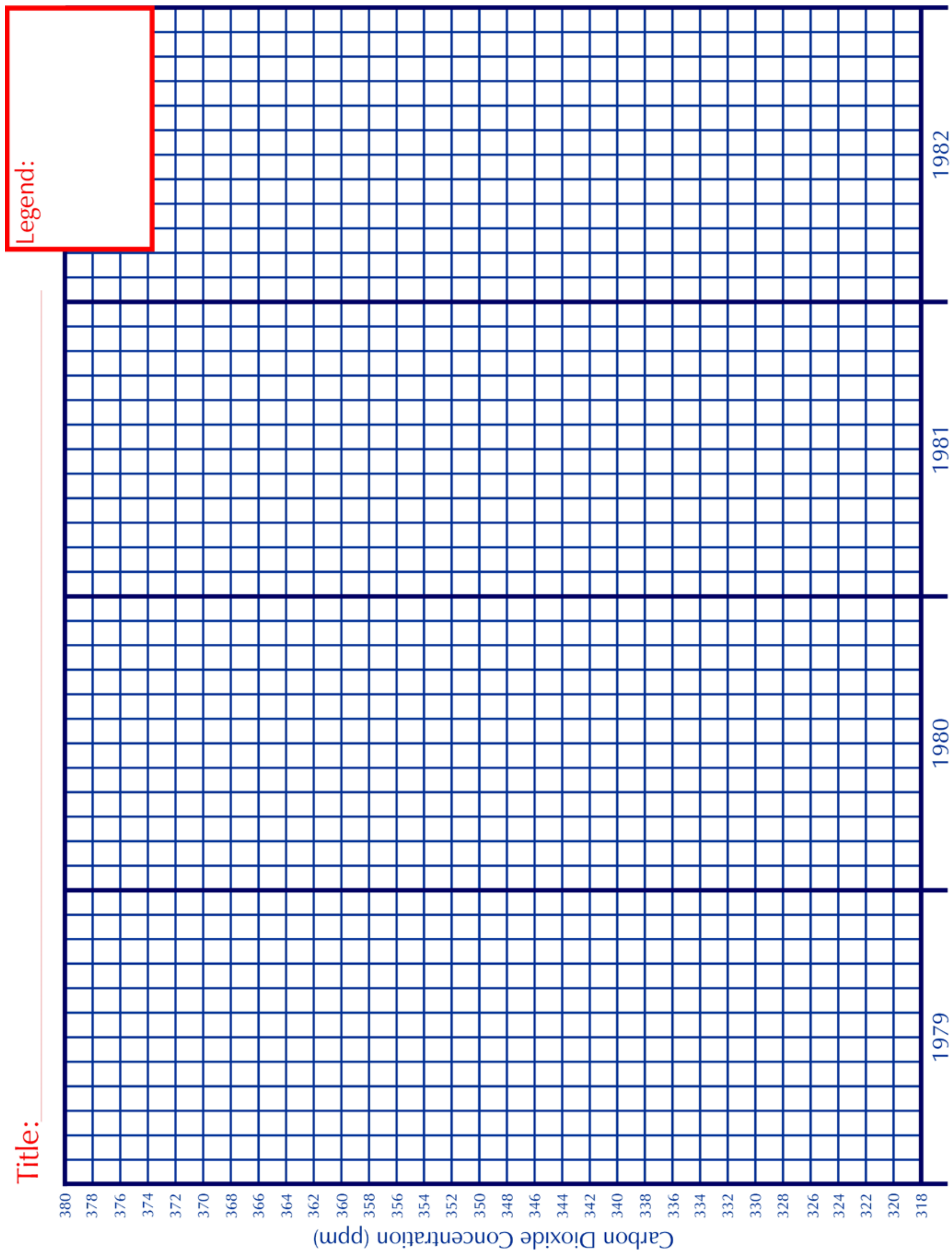


Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1971 - 1974

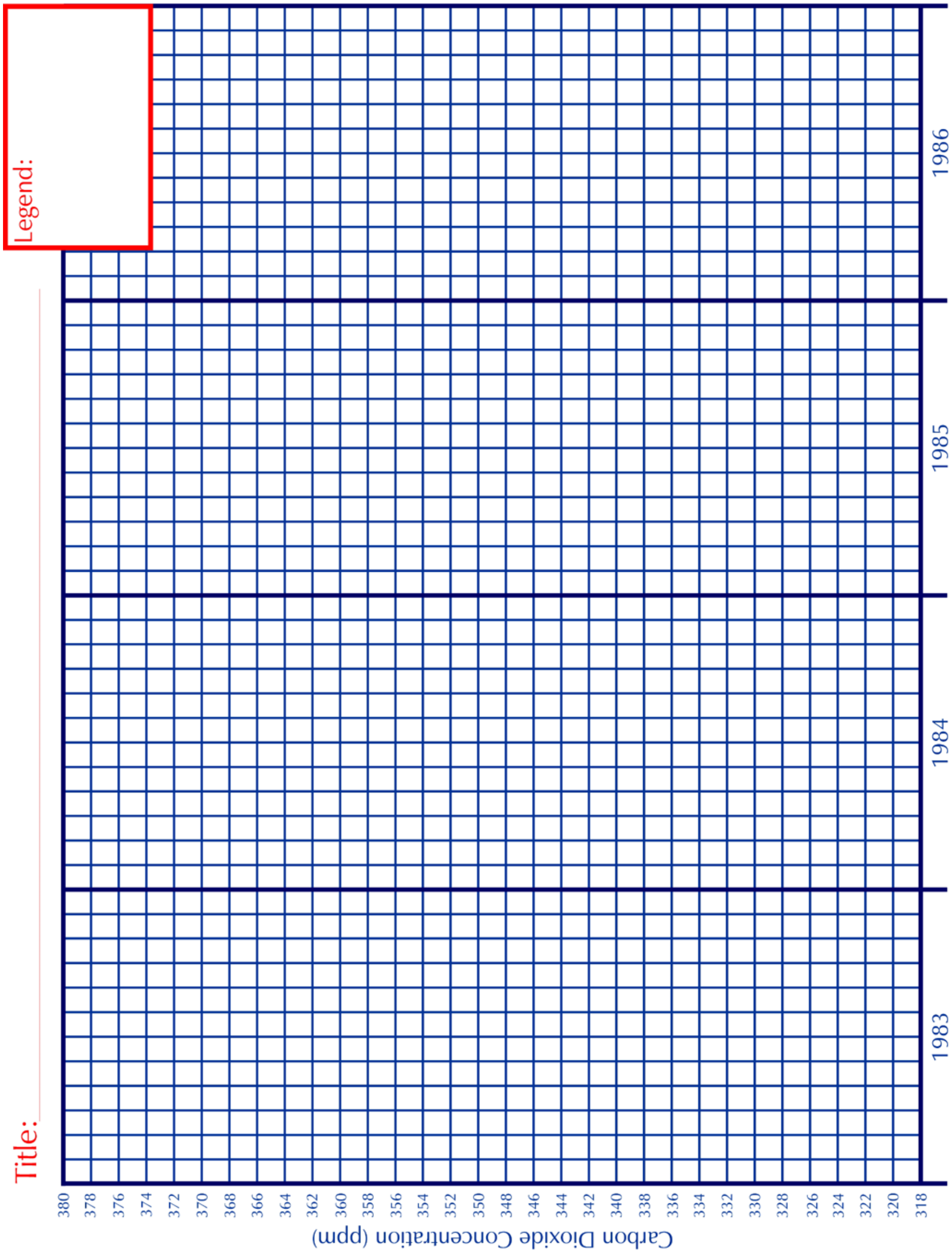
6-5



Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1975 - 1978

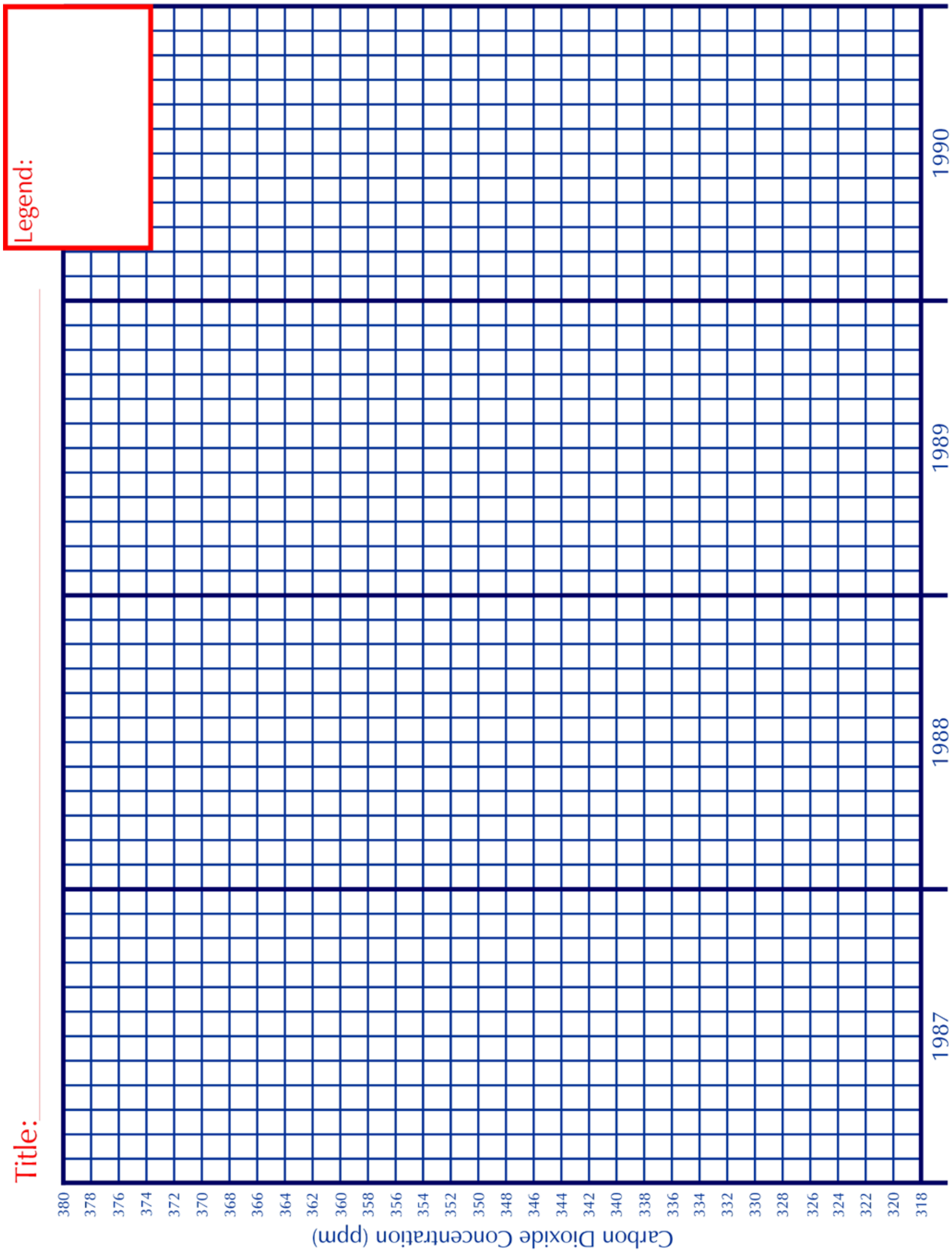


Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1979 - 1982

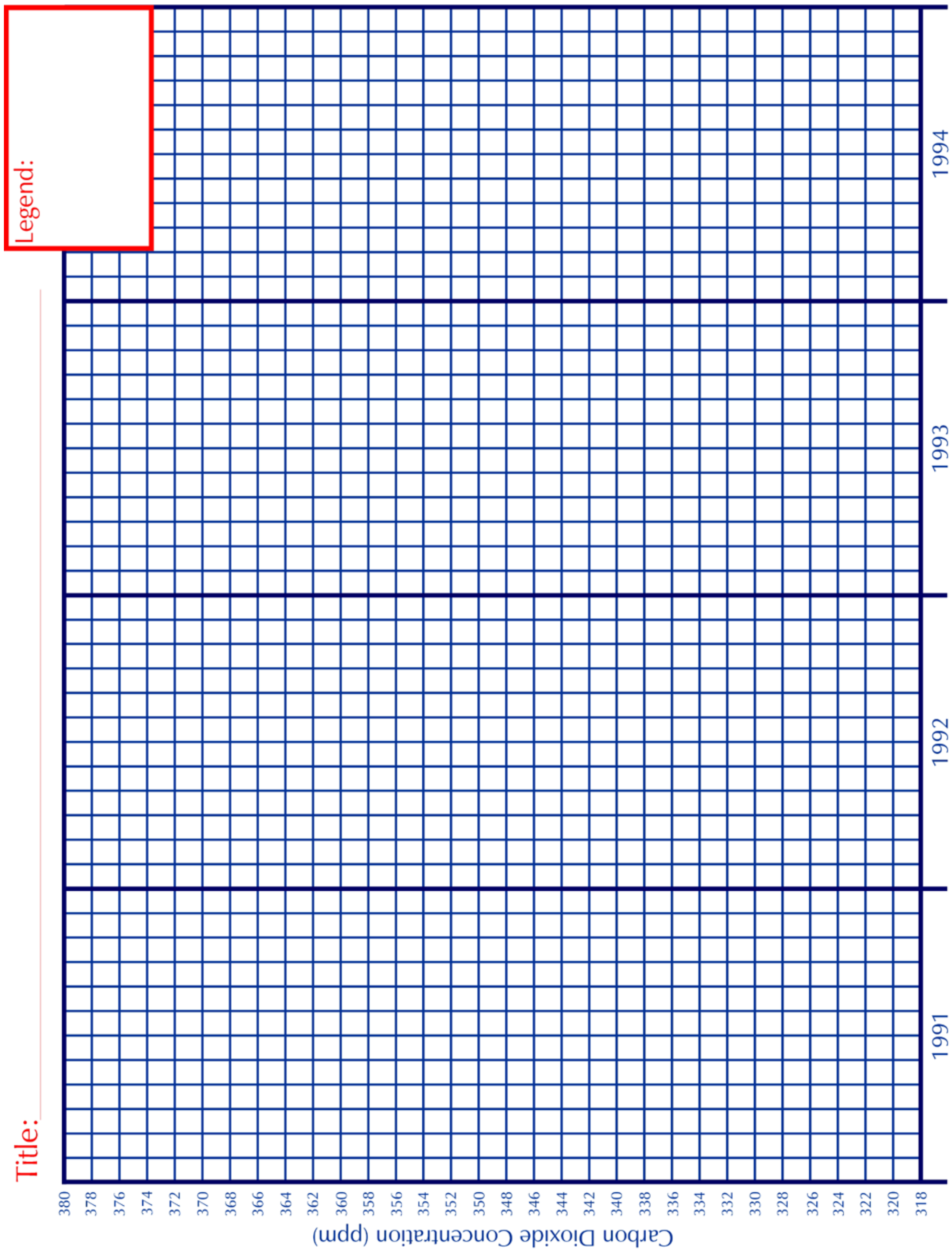


Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1983 - 1986

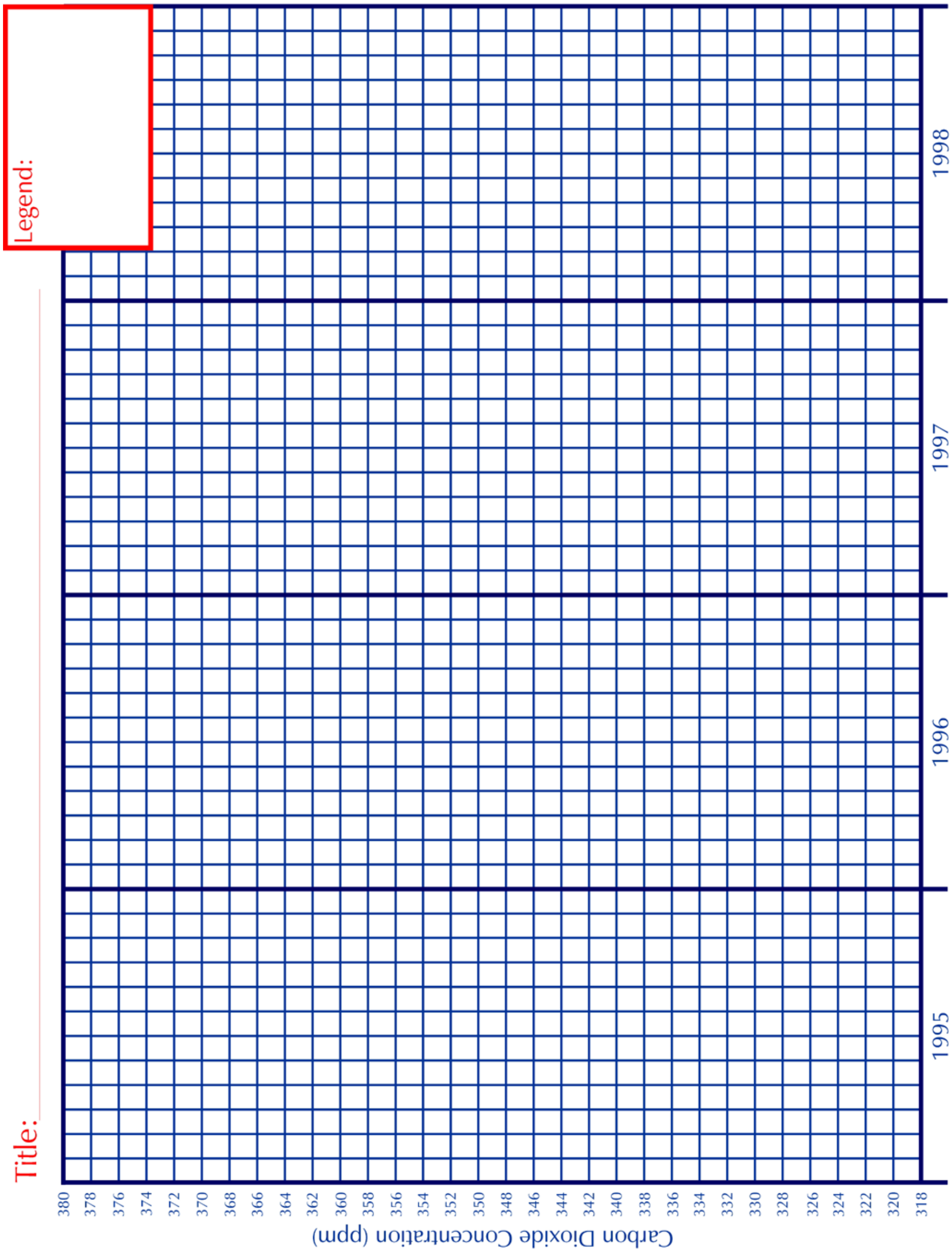
6-8



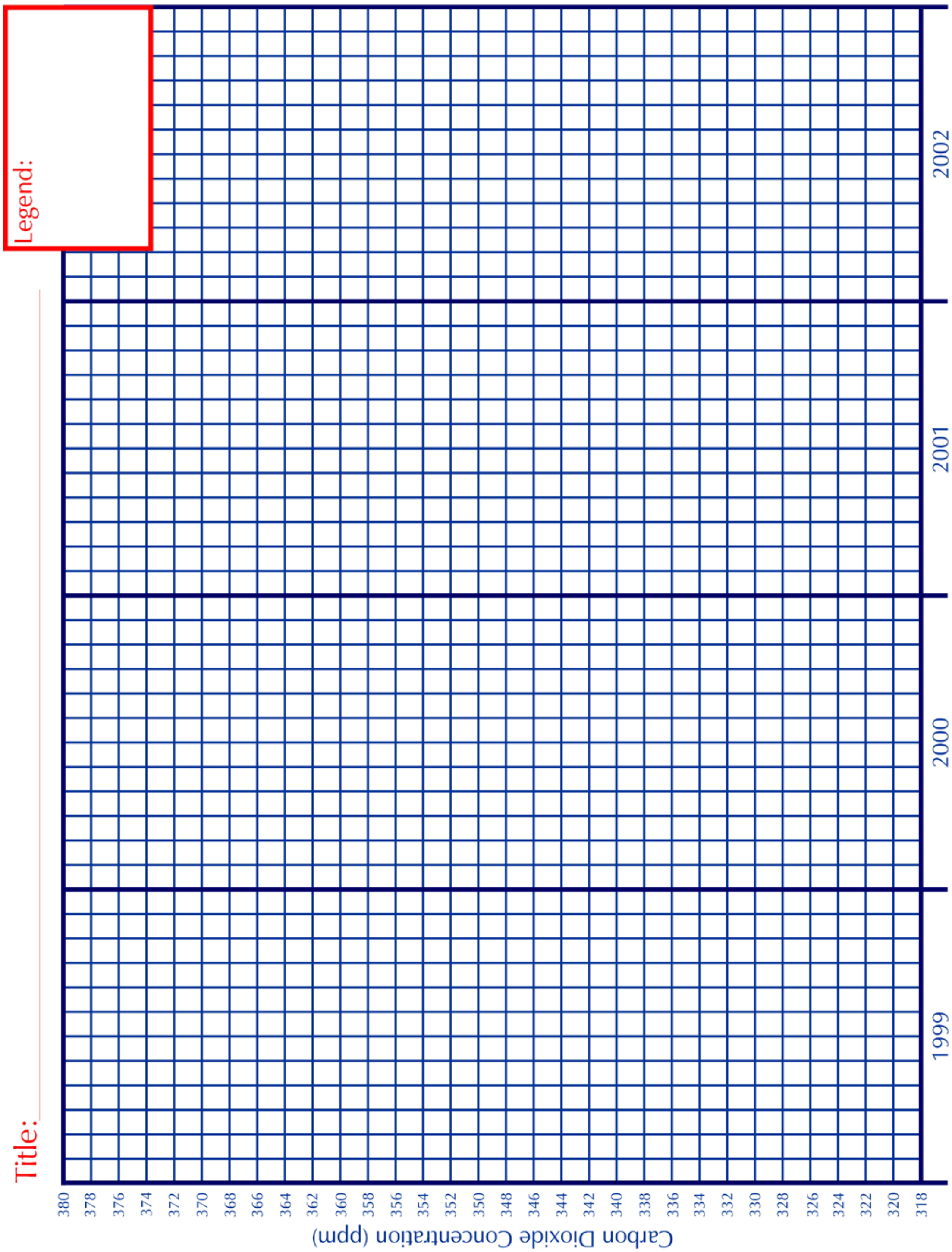
Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1987 - 1990



Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1991 - 1994



Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1995 - 1998



Point Barrow, Alaska and South Pole, Antarctica
Monthly Carbon Dioxide Concentrations : 1999 - 2002

FYI

Note

Concentration is measured in parts per million (ppm) for carbon dioxide and parts per billion (ppb) for methane. For example, a carbon dioxide concentration of 350 ppm means that there are 350 parts of carbon dioxide in a total of one million parts of air. A methane concentration of 1614 ppb means that there are 1614 parts of methane in a total of one billion parts of air.

Questions

Part A

1. During what season is the monthly mean CO_2 concentration greatest in Point Barrow, Alaska?

2. If you were in the Southern Hemisphere, during what season would the monthly mean CO_2 concentration be greatest at South Pole, Antarctica?

3. Why do CO_2 concentrations vary less at the South Pole than at Point Barrow?

4. Why do scientists collect CO_2 data at such remote isolated locations, such as Alaska and Antarctica?

Procedure
Part B

1. Using the data from Table 6.2, plot the points corresponding to the annual globally averaged annual mean CO_2 concentration on the graph that follows. Use a colored pencil to connect the points.

2. Using the data from Table 6.2, plot the points corresponding to the annual globally averaged annual mean CH_4 concentration on the graph that follows. Use a different colored pencil to connect the points.

3. Calculate the rate of change for the annual globally averaged mean CO_2 concentration. Use the following steps.

   a. First, subtract the lowest CO_2 concentration shown in Table 6.2 from the highest concentration.

   b. Next, subtract the oldest year in Table 6.2 from the most recent year, then add 1 to account for the first year. As an example, if you have data from 1955 - 1975, subtract 1955 from 1975, which equals 20, then add 1, which equals 21 years of data.

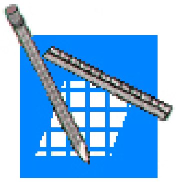
   c. Now divide the concentration from your first subtraction in 3a by the result of your calculation in 3b, the number of years you have data. The final result is the rate of change in concentration per year.

   d. Round off your result to the nearest tenth and enter it in the left box below the graph and label with units.

4. Repeat the procedures in 3a through 3d to find the rate of change for the annual globally averaged mean CH_4 concentration.

5. Print a title in the space provided above the graph.

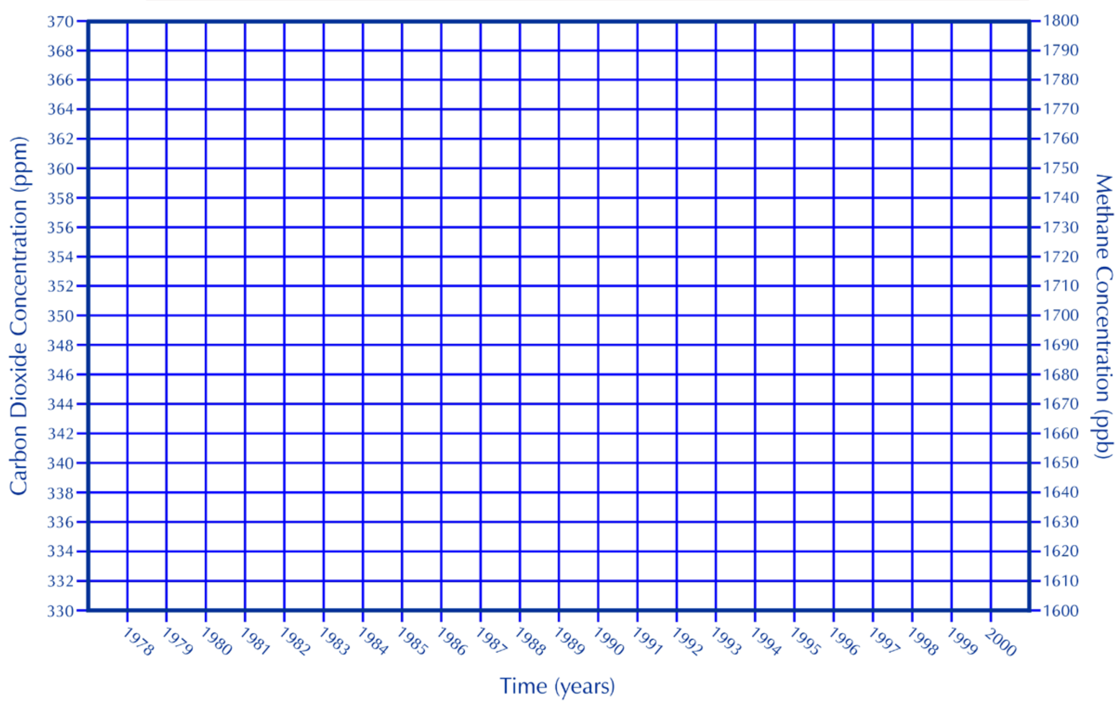
6. Draw a color-coded legend for your graph in the right box below the graph.



Year	1979	1980	1981	1982	1983	1984
CO_2 (ppm)	336.79	338.72	339.86	340.66	342.22	343.81
CH_4 (ppb)	------	------	------	------	------	1625.20
Year	1985	1986	1987	1988	1989	1990
CO_2 (ppm)	345.31	346.71	348.46	350.96	352.59	353.83
CH_4 (ppb)	1638.16	1650.45	1662.72	1672.80	1683.87	1693.40
Year	1991	1992	1993	1994	1995	1996
CO_2 (ppm)	355.19	355.85	356.60	357.94	359.83	361.59
CH_4 (ppb)	1703.67	1714.24	1715.76	1721.24	1727.81	1730.00
Year	1997	1998	1999	2000	2001	2002
CO_2 (ppm)	362.73	365.48	367.62	-----	-----	-----
CH_4 (ppb)	1733.42	1743.81	1751.44	-----	-----	-----

Table 6.2. Globally Averaged Annual Mean CO_2 Concentrations (ppm) and CH_4 Concentrations (ppb)

Title:____



Carbon Dioxide Rate of Change:

Methane Rate of Change:

Legend:

Globally Averaged Annual Mean CO_2 Concentrations (ppm) and CH_4 Concentrations (ppb)

SAM II 6-15

FYI

For Your Information

Globally averaged carbon dioxide and methane monthly and annual values take data from every available source. Statistical algorithms (mathematical equations) are then used to make all data values equivalent (having equal power, value, force, or meaning). Then the averages are computed. Globally averaged calculations are our best values for the given parameters (carbon dioxide and methane in this case) over the entire Earth.

Questions

Part B

1. What happened to the CO_2 and CH_4 concentrations between 1979 and 1999?

____

____

2. Does CO_2 or CH_4 show the greatest rate of change relative to each other?

____

Explain.

____

____

____

____

____

3. Do these data alone support the idea of global warming?

Explain.

Conclusion

Review the problem stated on the first page and write a detailed conclusion here and on the next page (if necessary).